

Recent Results from **BRAHMS** experiment at RHIC

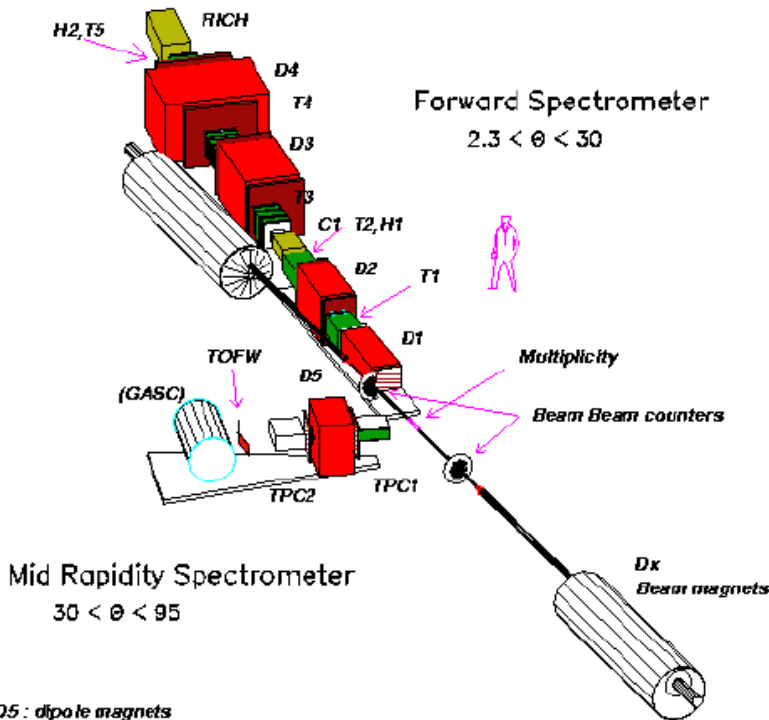
J.H. Lee
BNL
for BRAHMS Collaboration



**Workshop on Thermalization and Chemical
Equilibration in Heavy Ions Collisions at RHIC
BNL, July 20, 2001**

BRAHMS

Broad Range Hadron Magnetic Spectrometer



D1, D2, D3, D4, D5 : dipole magnets
T1, T2, T3, T4, T5, TPC1, TPC2 : tracking detectors
H1, H2, TOFW : Time-of-flight detectors
RICH, GASC : Cherenkov detectors

➤ Measures Charged Hadrons over a Wide Angular and Large Momentum Range with High Precision

➤ 2 Movable Spectrometers (Mid-rapidity Spectrometer and Forward Spectrometer)

➤ Centrality Detectors: Tiles, Silicon Strips, Beam-Beam counters, Zero-degree Calorimeters

➤ Collaboration of ~55 Physicists from 11 institutions

BRAHMS Collaboration

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Johns Hopkins University, Baltimore, USA⁵

New York University, USA⁶

Niels Bohr Institute, University of Copenhagen, Denmark⁷

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University of Bucharest, Romania⁹

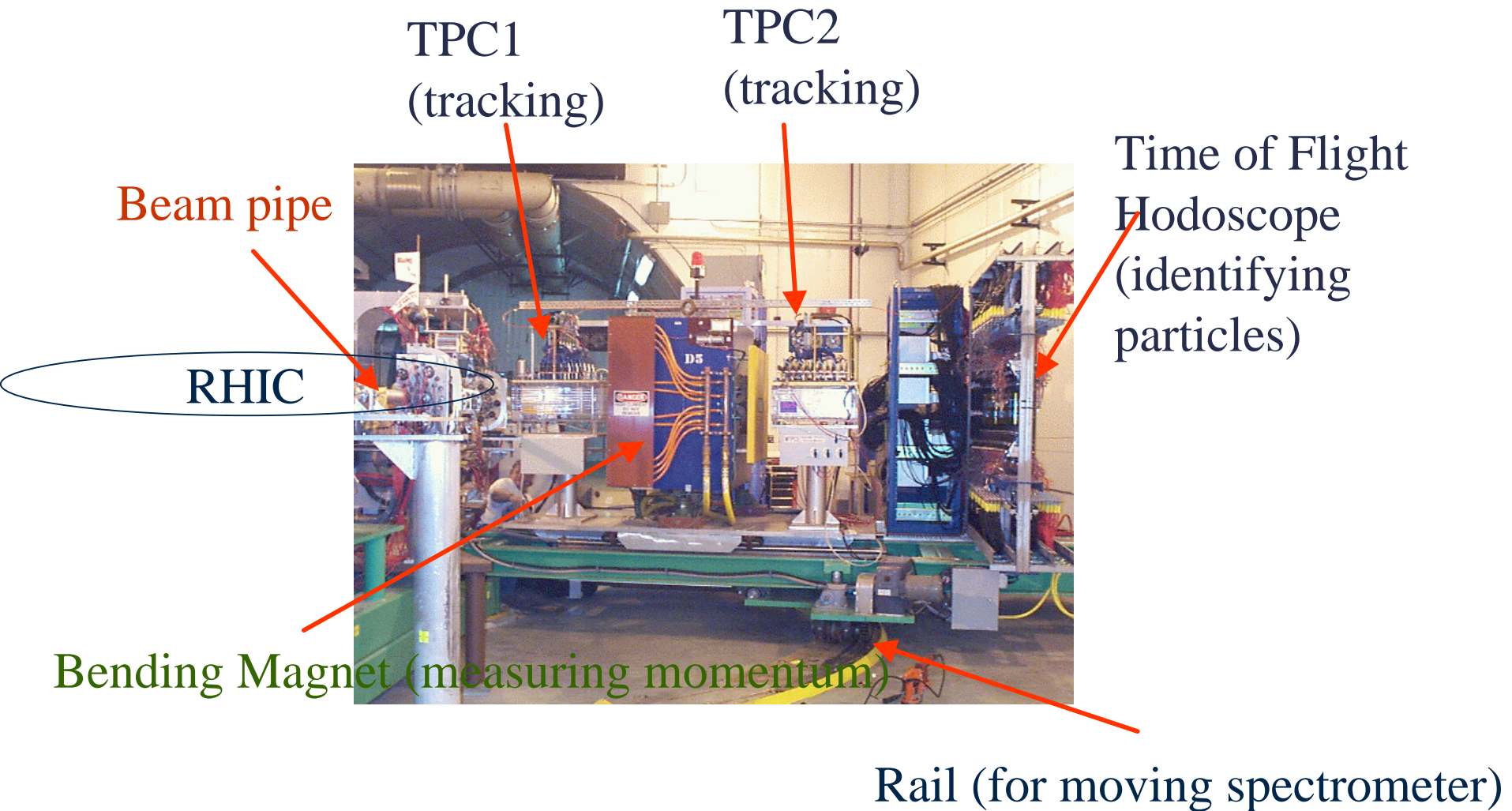
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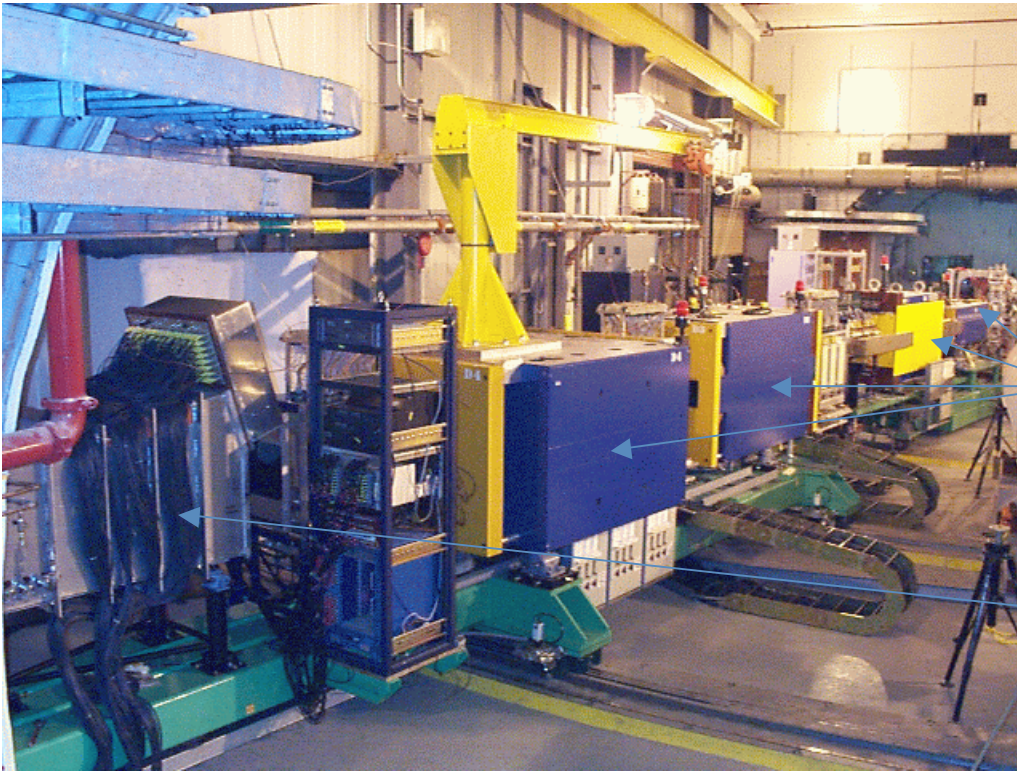
Mid-rapidity Spectrometer

(rotates 30° - 95°)



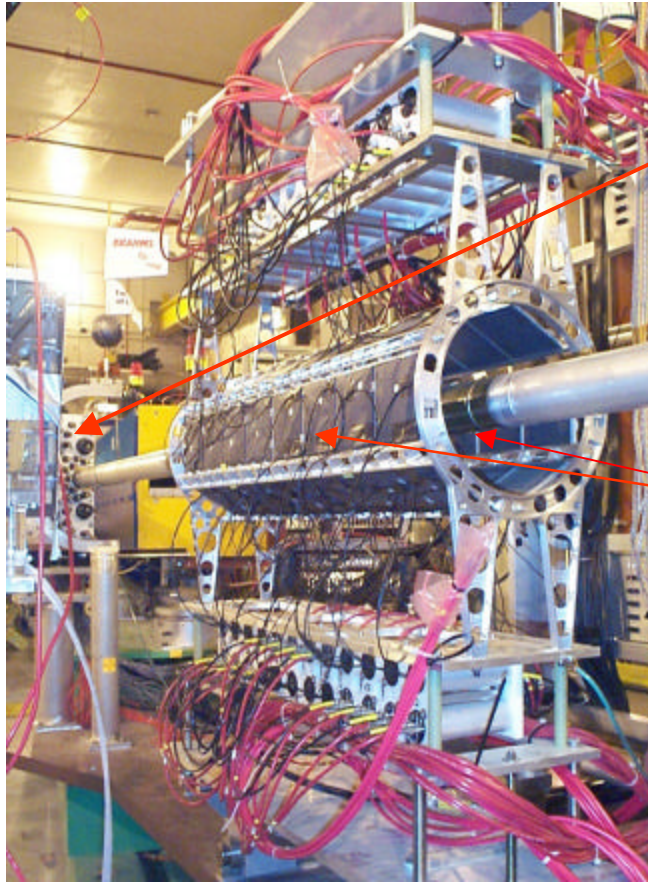
Forward Spectrometer

(rotates 2.5° - 30°)



- ~20 m long
- TPC's: **T1** and **T2**
- DC's: T3,T4,T5
- Magnets: **D1,D2**,D3,D4
- ToF Hodoscopes: **H1**, H2
- Cerenkov Counter: C1
- RICH

Global Detectors



- Beam-Beam Counters
 - Provide a start time and on-line trigger
 - Measure multiplicity at high η ($2.1 < |\eta| < 4.7$)
- Multiplicity Detectors (Tile and Si Arrays)
 - Provide charged particle multiplicity ($-3 < \eta < 3$)
 - Used to characterize centralities of events
- Zero Degree Calorimeters

BRAMS Physics Goals

Probing Hot and Dense Nuclear Matter at RHIC by studying

- ✦ Reaction Mechanism and dynamics
- ✦ Baryon Stopping
- ✦ Particle productions

Through measurements of

- ✦ Identified hadrons over wide range of rapidity, $0 < |y| < 4$ and $0.2 < p_t < \sim 4\text{GeV}/c$ vs collision centrality with high precision.

First year run only covers a small part of the landscape.

Summary of BRAHMS data from the first year ('00) running

Data

- # Au+Au at $\sqrt{s_{nn}}=130$ GeV
- # Limited luminosity (<10% of designed) with wide collision vertex distribution ($\sigma \sim 65$ cm)
- # Selected Spectrometer settings (MRS at $90^\circ, 40^\circ$ FS at 4°)

Measurements

- # Charged Particle Multiplicity ($dN/d\eta$)
- # Hadron Yields
- # Particle/anti-particle Ratios (π , K, p)

BRAHMS Publications

- ✦ “Rapidity dependence of anti-proton to proton ratios in Au+Au collisions at $\sqrt{s_{nn}}=130$ GeV”

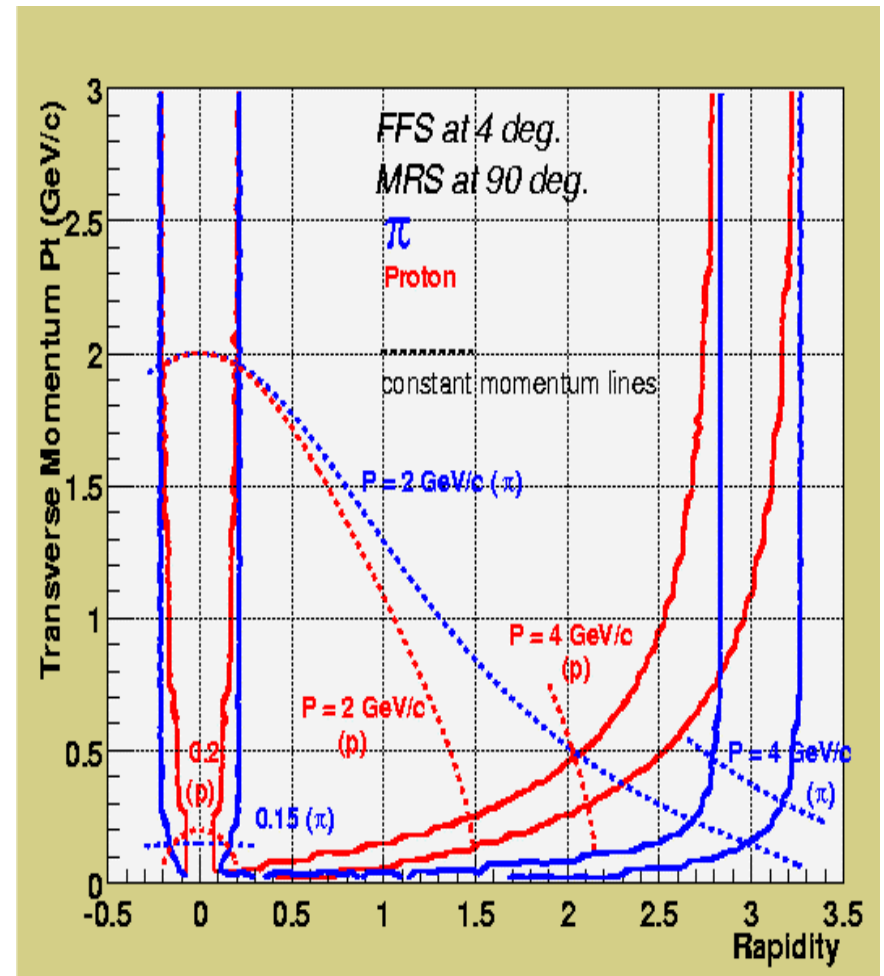
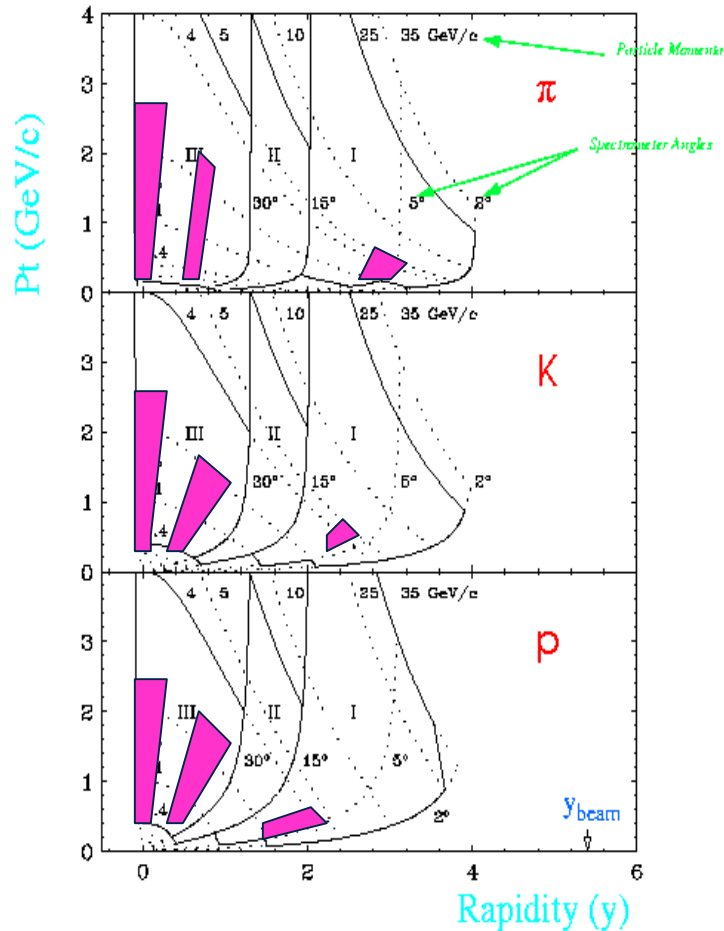
Accepted for publication in PRL : nucl-ex/0106011

- ✦ “Charged particle densities from Au+Au Collisions at $\sqrt{s_{nn}}=130$ GeV”

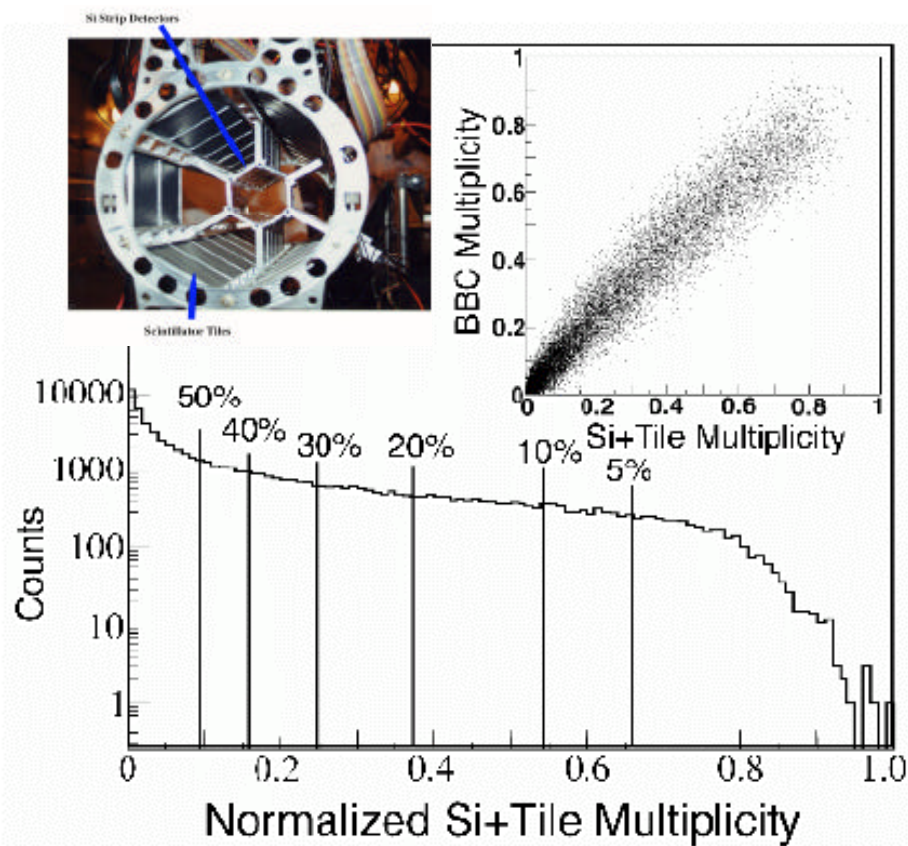
Will be submitted to PLB

- ✦ More information in <http://www.rhic.bnl.gov/brahms>

BRAHMS acceptance (August 2000)

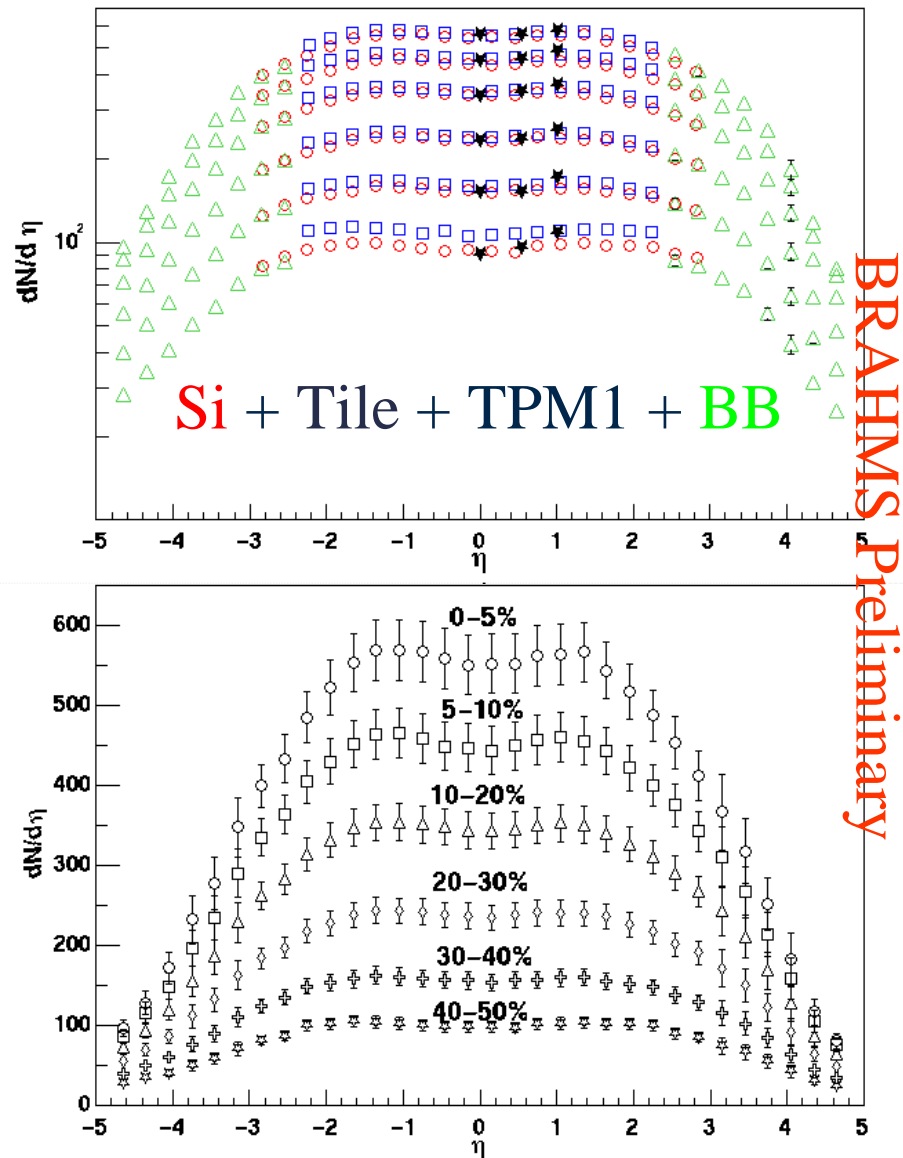


Collision Centrality Determination



- Measured by the Centrality Detector (Si+Tile)
- Corrected for Vertex position dependence
- Minimum-biased multiplicity: Data + MC (HIJING+GEANT)
- BB Multiplicity is used for the centrality determination for BB analysis (consistent with Si+Tile selections)

$dN_{ch}/d\eta$ measurement



■ Using
Si+Tile+TPM1+BB

■ Centrality Cut:
Si+Tile and BB

■ $-4.7 < \eta < 4.7$

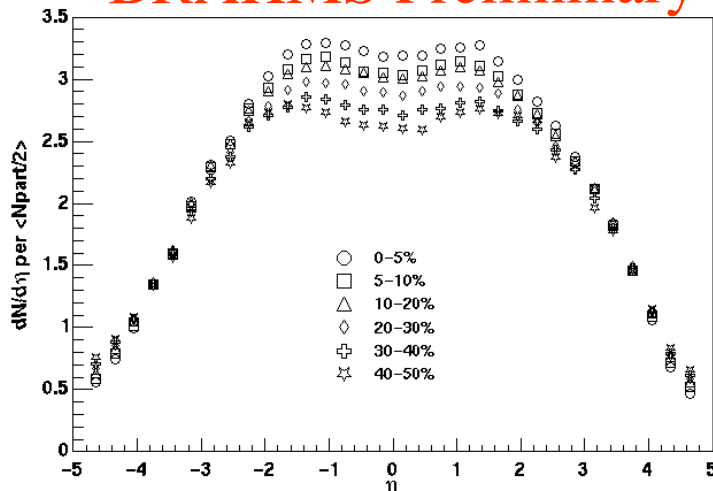
■ Most Central (0-5%)

- $dN/d\eta = 549 \pm 1 \pm 35$
at $y \approx 0$

- $\int N_{ch} d\eta = 3855 \pm 297$
for $|\eta| < 4.7$

N_{ch} vs. participant nucleon pairs

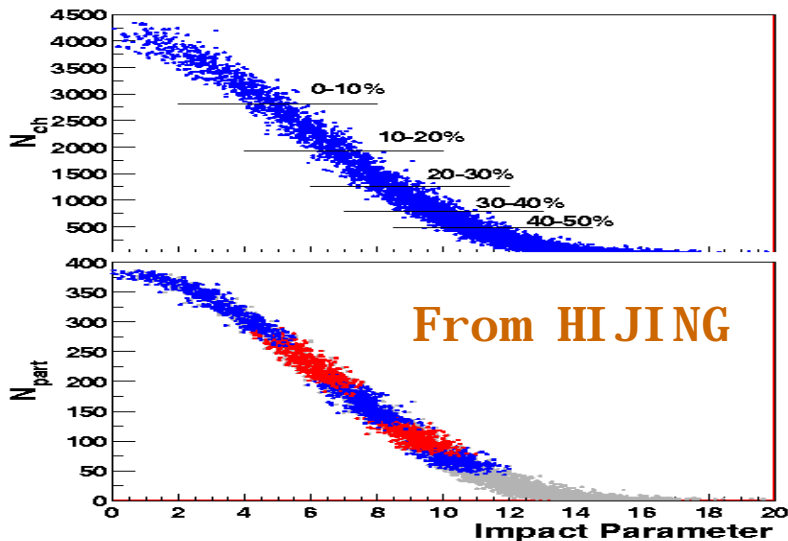
BRAHMS Preliminary



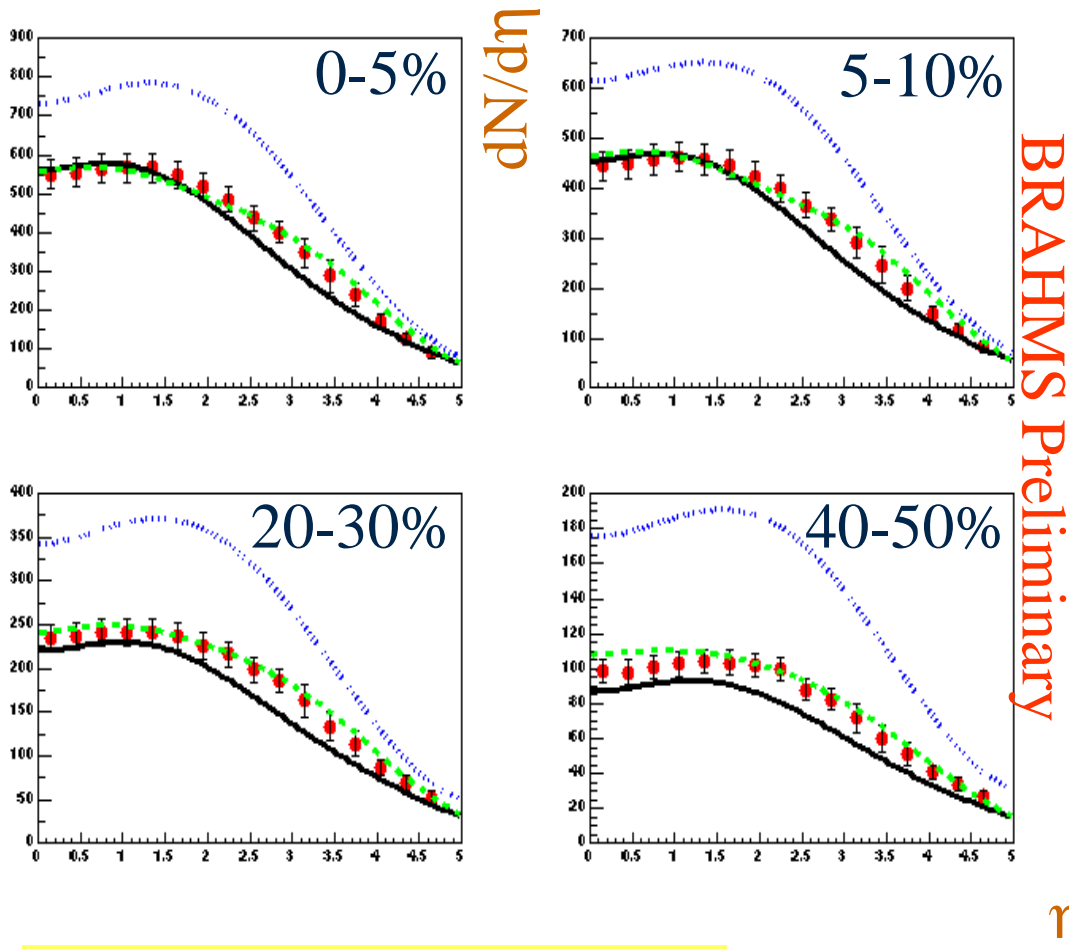
■ $dN/d\eta \sim 3.2$ per participant nucleon pair at $\eta=0$ for central (0-5%); $\langle N_{\text{part}} \rangle = 346$

■ Enhancement of particle production for central collisions at mid-rapidity

■ At high rapidities ($\eta > 3$) particle production scales with N_{part}



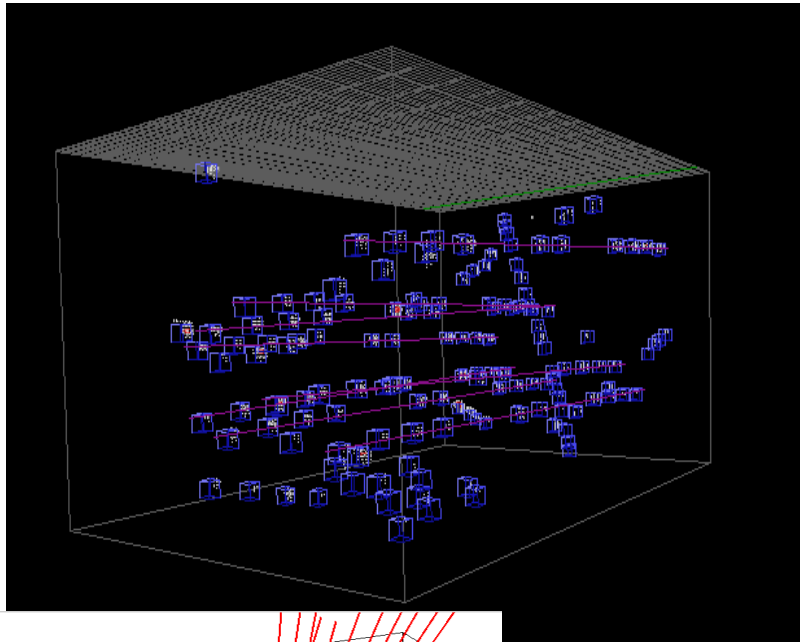
$dN_{ch}/d\eta$ and Model Predictions



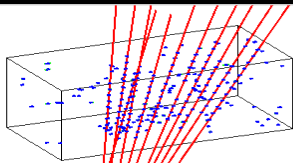
- HIJING: good agreements at mid-rapidity
- AMPT: good agreements in $\Delta\eta$
- UrQMD: reproduce shape well

UrQMD, AMPT, HIJING

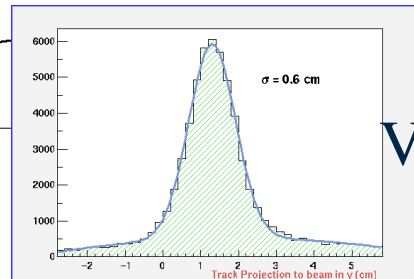
Track Reconstruction



- Tracking: 2 TPC's
- Track selection: tracks from production vertices consistent with global vertex in x and y
- Momentum determination: from matching angle in the bending magnet

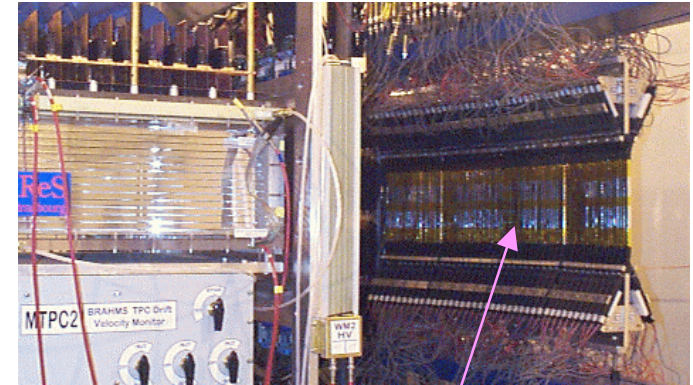
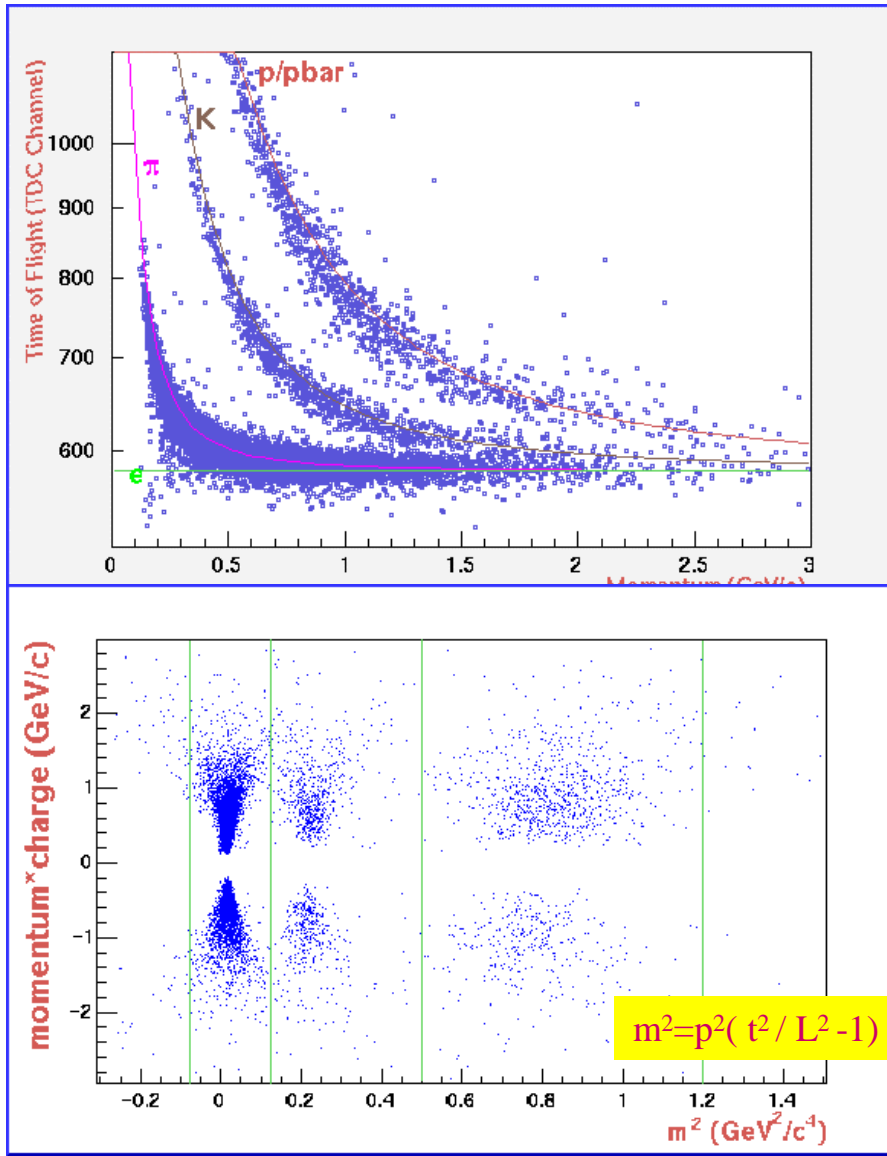


Vertexing



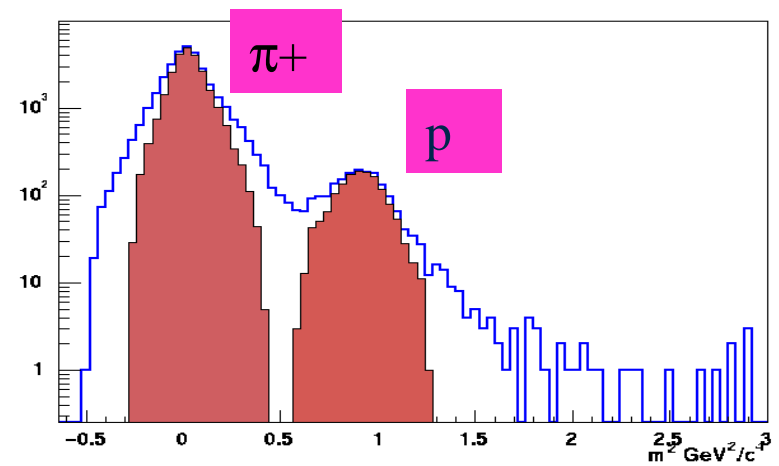
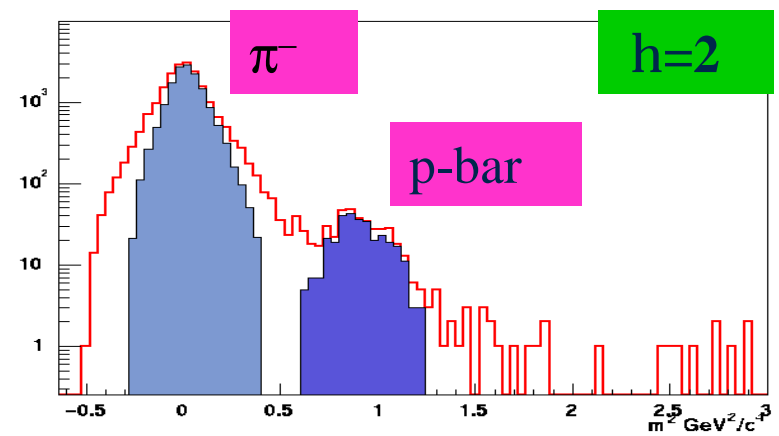
Vertex y-matching

Particle Identification in Mid-Rapidity Spectrometer

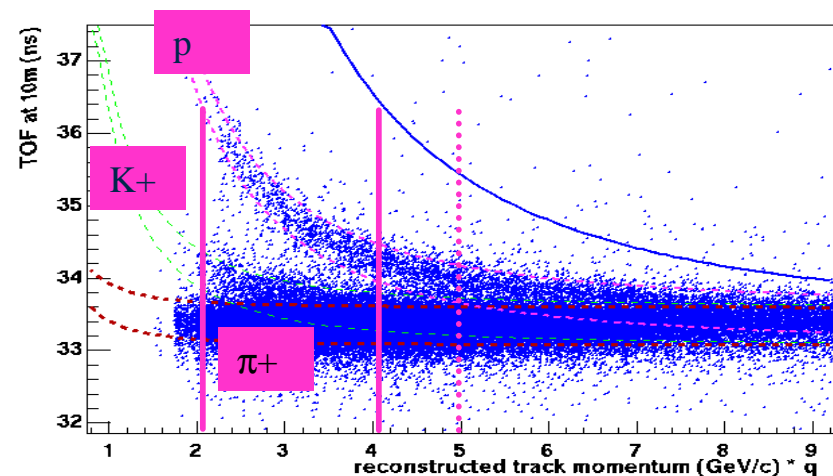


- # Using Time of Flight Hodoscope
- # Proton and K, π separation up to ~ 2.5 GeV/c
- # K and π separation ~ 1.5 GeV/c
- # Electron and muon “contamination” in π $< 2\%$

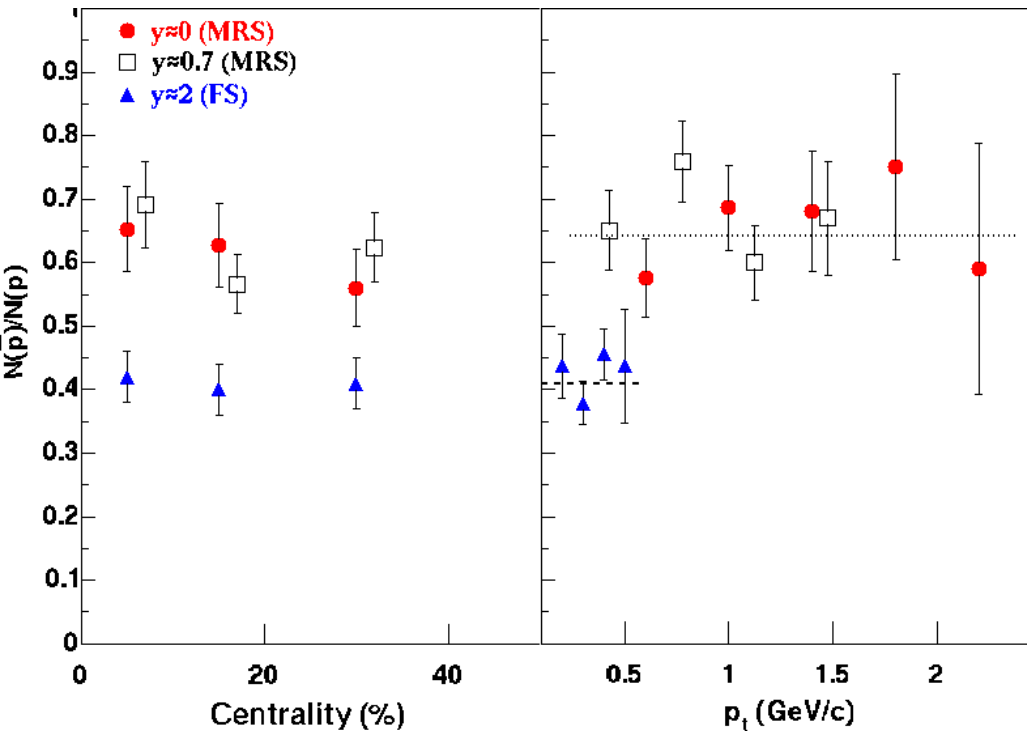
Particle Identification in FS



- More difficult due to background, higher momentum, path length determination
- Cerenkov Detectors (C1 and RICH) and a secondary ToF counter (H2) will identify higher momentum (up to 25 GeV) in '01 run



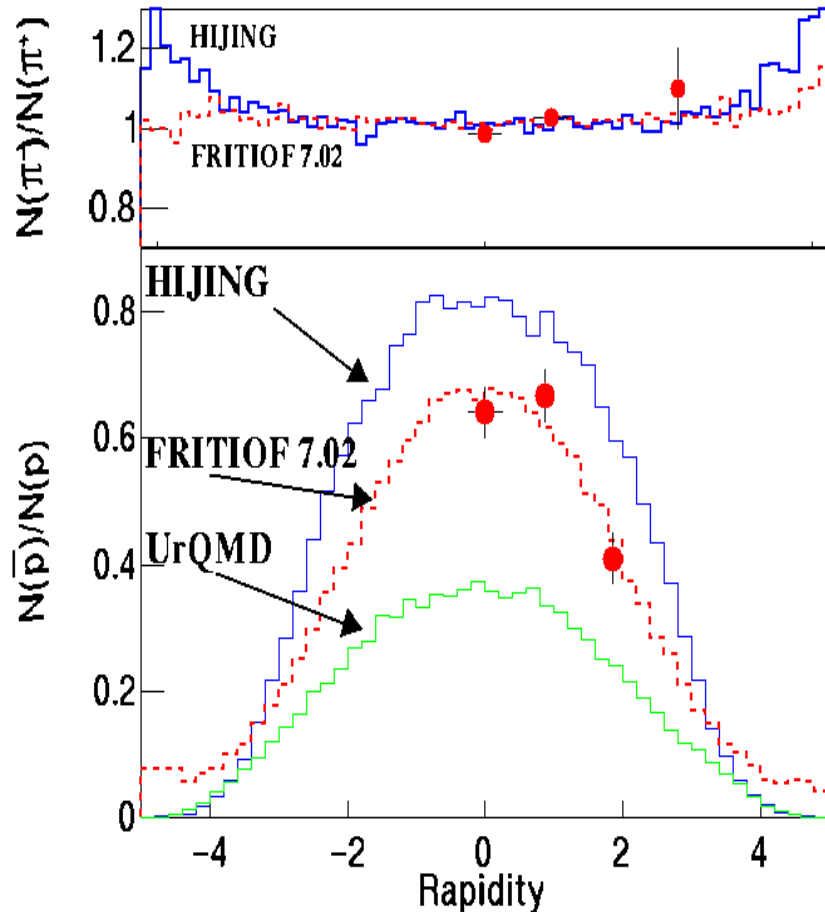
N(pbar)/N(p) ratio



- # Acceptance and most of the systematic differences “cancel out”
- # Antiproton absorption correction to pbar/p ratio:
 - 5 % for FS at 4 deg
 - 2 % for MRS at 90, 40 deg
- # 10% corr. (low pt) **p** from secondary interactions
- # Most pbar and p from **Hyperon decays** fall into spectrometer acceptance.
 - Correction factor depends on H/B, H-bar/B-bar
 - For $H/B < 0.5$ systematic correction is $< \pm 5\%$ on ratio
 - Model dependent \Rightarrow not applied to data
- # No strong centrality and pt dependence observed

$0.64 \pm 0.04 \pm 0.06$ at $y \sim 0$
 $0.66 \pm 0.03 \pm 0.06$ at $y \sim 0.7$
 $0.41 \pm 0.04 \pm 0.06$ at $y \sim 2$
 for 0 - 40% central

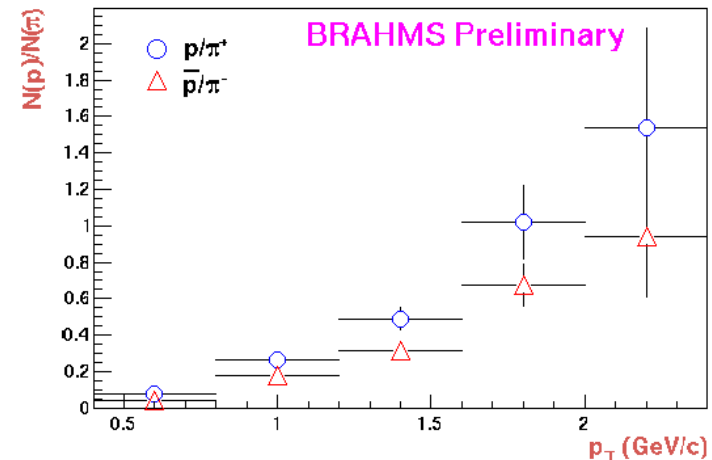
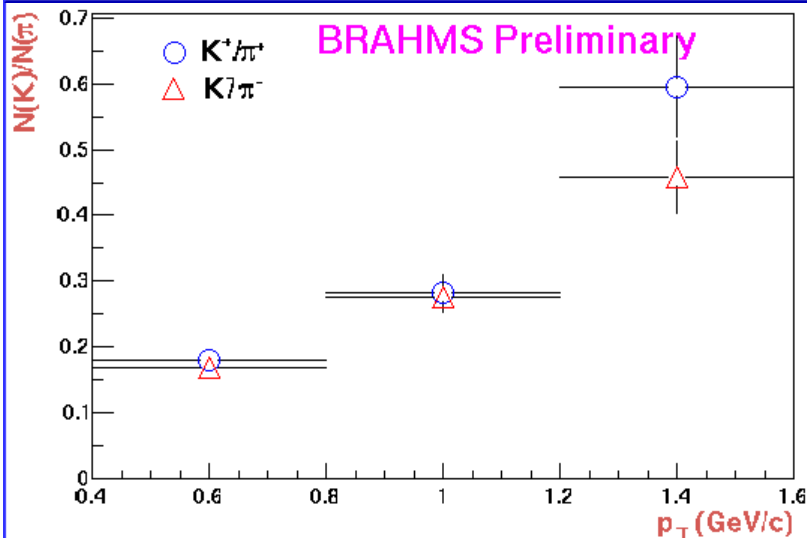
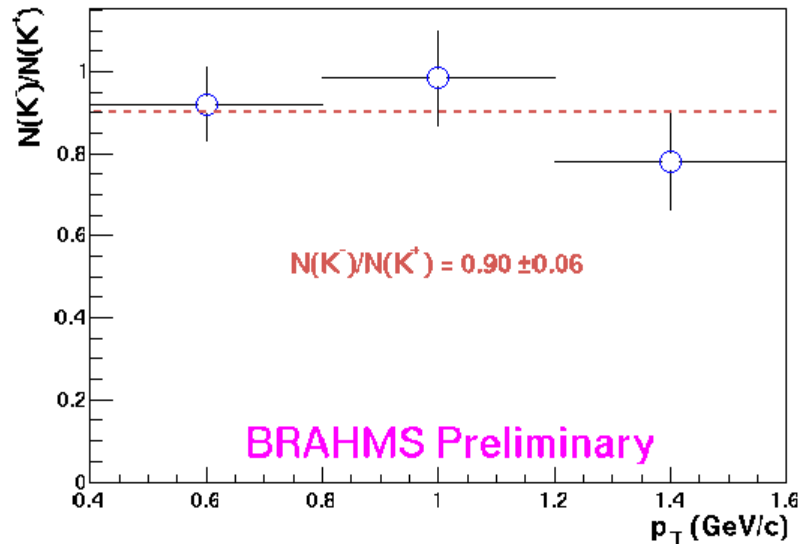
$N(\bar{p})/N(p)$ and Models



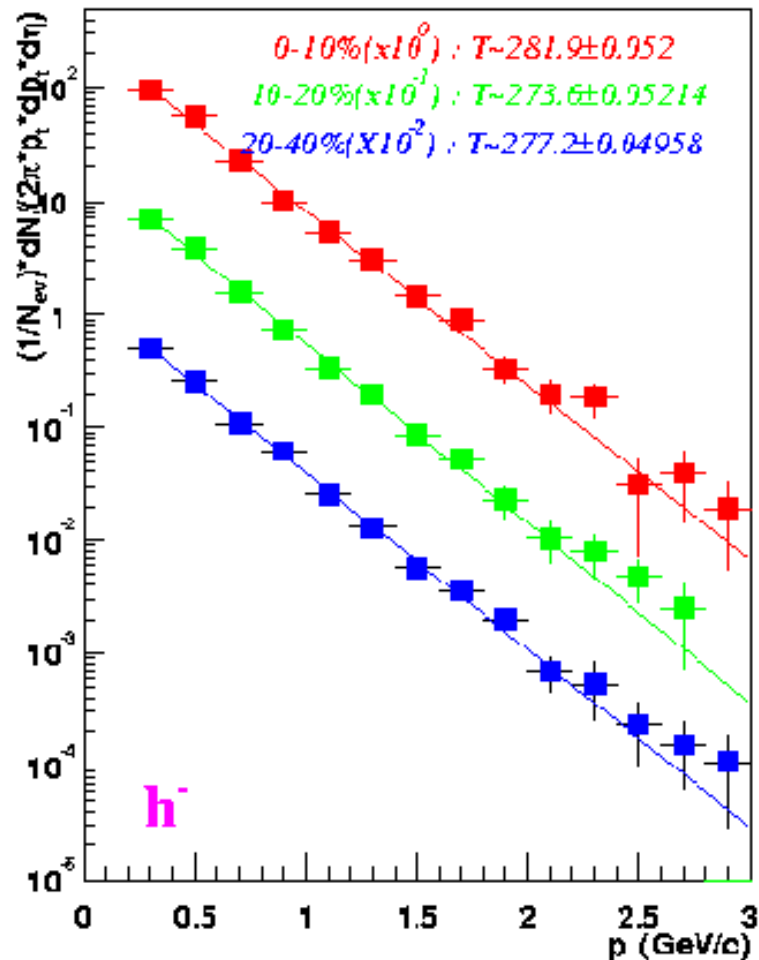
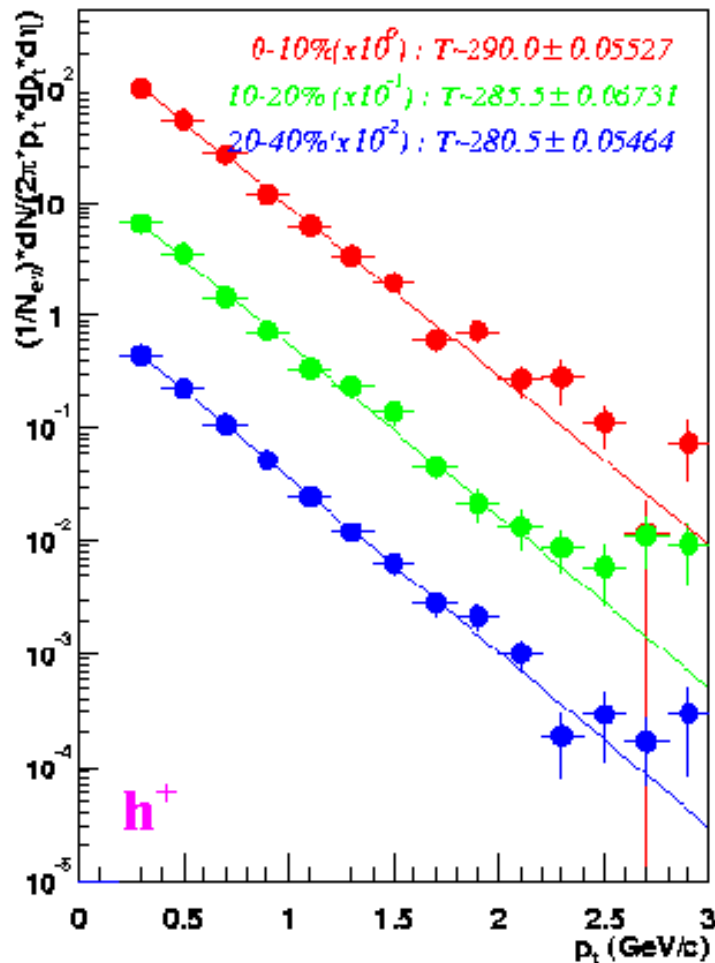
- Near constant (≈ 0.65) at $|y| < 0.7$
- Drops fast between $y = 1$ and 2 faster than at SPS energy ($\sqrt{s_{NN}} = 17$ GeV) similar as pp ($\sqrt{s_{NN}} = 63$ GeV)
- More baryons than HIJING prediction for $|y| < 2$
- Good agreements with FRITIOF

More Ratios (at $y \approx 0$)

- 0-40% central
- $N(K^-)/N(K^+) = 0.90 \pm 0.06$
- $N(K)/N(\pi)$: 0.2 – 0.5
increase with p_t
- $N(p)/N(\pi)$ 0.1 – 1.4
 $\bar{p}(p) > \pi^-(\pi^+)$ "anomaly"?
for $p_t > 2$ GeV/c (nucl-th/104066)



Charged Hadron Spectra



BRAHMS Preliminary

Summary

The first year of RHIC running, Au+Au at $\sqrt{s_{nn}} = 130$ GeV has yield a first set of good quality data. BRAHMS measured charged particle multiplicities and particle/anti-particle ratios.

- # $dN/d\eta \approx 550$, $(dN/d\eta)/(0.5*N_{part})=3.2$ at $y \approx 0$ for central
- # Enhancement of particle production for central collisions at mid-rapidity
- # $N(pbar)/N(p)$: Near constant at 0.65 in $|y| < 0.7$ and 0.41 at $y \approx 2$
- # $N(K^-)/N(K^+) = 0.9$ and $N(p)/N(\pi) > \sim 1$ at $p_t > \sim 2$ GeV/c
- # Models describe data partially

BRAHMS: Ready to Play A Main Program in 2001 Run

Systematic Survey of identified particle spectra and yields as functions of Rapidity ($0 < y < 4$), p_t ($< 1.3 \text{ GeV}/c$) (“Soft” Physics) and Multiplicity ($dN/d\eta$) measurements in Full RHIC energy Au+Au at $\sqrt{s_{nn}} = 200 \text{ GeV}$

High p_t ($1-4 \text{ GeV}/c$) (“Hard” Physics) and HBT measurements at selected rapidities
And More.

Investigate pp physics

STAY TUNED!

